Space Weather Technical Forecast

Issued on Tuesday, 05 December 2023 at 01:26 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance G1/Minor-Geomagnetic Storm early Day 1. Chance of isolated M-Class flares (R1-R2 Blackouts) Days 1-2.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Low with the largest flare of the past 24 hours a C8.1 flare at 04/0126 UTC from AR3511. There are currently nine sunspot regions on the disc. AR3500 is now on the southwest limb, and after a period of activity when it was centre disc, has been largely inactive. AR3510 (Dai/Beta) and AR3511 (Dai/Beta-Gamma-Delta), in the southeastern quadrant are now approaching centre disc and are the most magnetically complex regions on the disc, with a delta spot in the centre portion of the latter sunspot. AR3507 (Dso/Beta), is the largest region on the disc and has continued to develop, with a number of several smaller spots of mixed polarity emerging to the south of the main large spot. The remaining regions on the visible disc are mature and stable or in slow decay.

Despite a number of CME signatures evidenced in coronagraph imagery during the past 24 hours, none are considered Earth-directed. However, a filament eruption from near AR3511 around 04/07000 UTC produced a CME that may give a glancing blow on Day 3 (07 Dec).

Solar Wind / Geomagnetic Activity: Solar wind parameters have been indicative of the steady arrival of a high-speed stream from coronal hole, CH76/-. Solar wind speeds, as observed by DSCOVR at L1, have been at elevated levels throughout, varying between 520-560 km/s. Density was largely between average and above average levels, with a peak of 22ppcc at 04/0714 UTC. The Interplanetary Magnetic Field (IMF), Bt, was initially weak before rising to moderate levels after 04/0500 UTC. Since around 04/1540 UTC IMF has increased more steeply and peaked at 15nT at around 04/2300 UTC. The north-south component of the IMF (Bz), was largely positive, fluctuating between +9/-9nT. Phi angle has been predominantly negative (towards the Sun). Resultant Geomagnetic activity was Quiet throughout (Kp 1-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux has been Background. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu) with a steady trend. The observation at 05/0000 UTC was 1.49e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low with a chance for isolated M-flares (R1-R2 Blackouts) Days 1-2 (05-06 Dec), reducing to a slight chance on Days 3-4 (07-08 Dec). One region is set to depart the disc during Day 1, with a new region then expected to emerge from the eastern limb that has already produced a number of C-flares.

Solar Wind / Geomagnetic Activity: A CME that left the Sun on 01 Dec is expected to give a glancing blow at Earth early Day 1 (05 Dec). A filament eruption that left the Sun around 04/0700 UTC is expected to miss, but there is a slight chance of a glancing blow on Day 3 (07 Dec). No further CMEs are currently thought to be Earth-directed.

Enhancement of solar winds from the HSS from CH76/- is expected to persist through Days 1-2 (05-06 Dec) with winds at Elevated levels, possibly peaking around 600-620km/s Day 1. Winds are expected to slowly return to Slightly Elevated levels on Day 3 in the absence of any further

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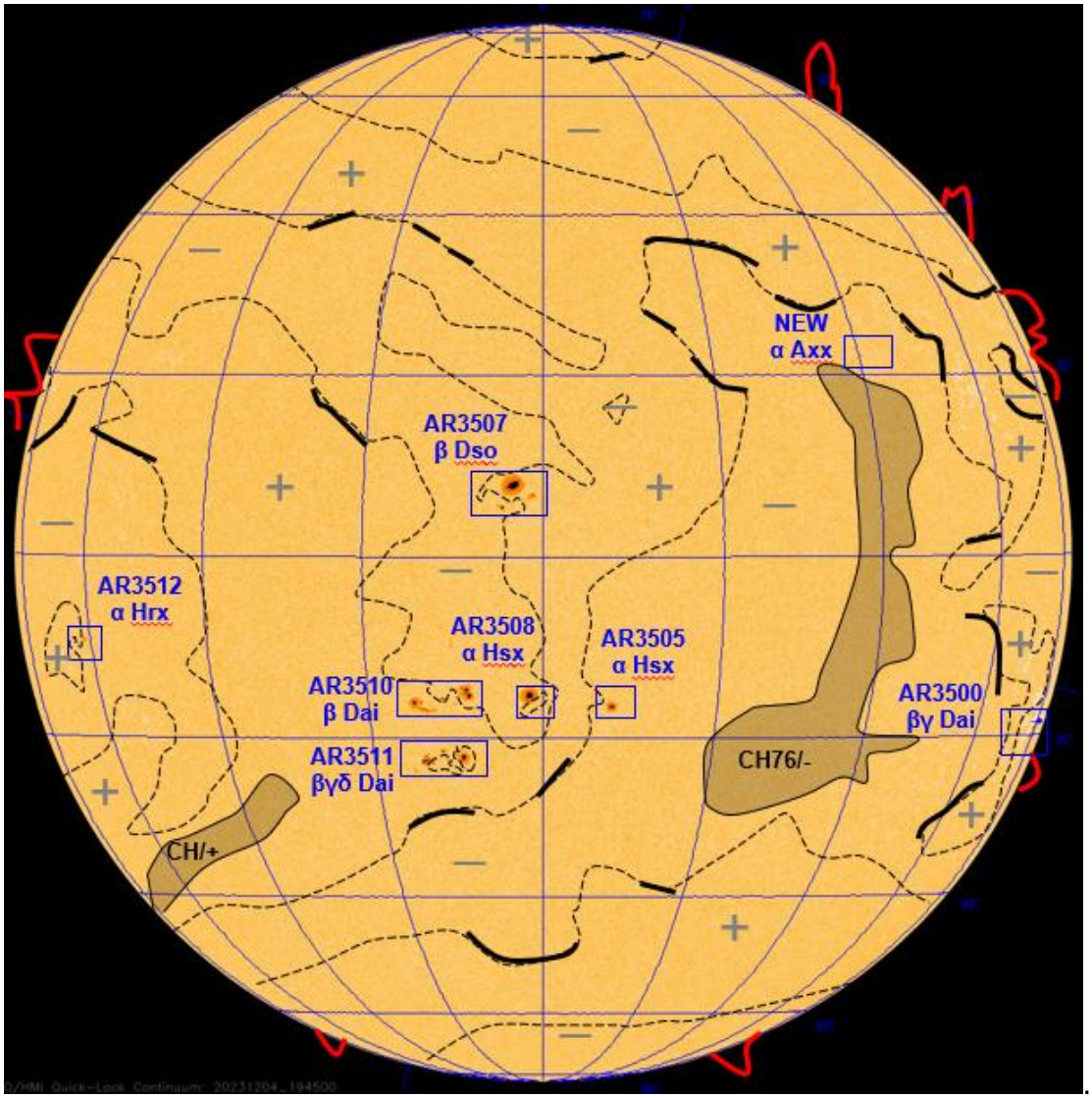
CME enhancement.

Geomagnetic activity is expected to be largely Quiet to Unsettled (Kp 0-3) through the forecast period There is a chance in the early hours of Day 1 that a combination of influences from the HSS and a potential CME arrival may see activity increase to Active (Kp 4) or G1/Minor Geomagnetic Storm (Kp 5) levels. There is a slight chance on Day 3 (07 Dec) that a glancing blow from a CME produce an Active or G1/Minor Geomagnetic Storm interval, but this is considered a low probability, with Enlil modelling a miss below Earth's orbit.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is forecast to remain at background levels with no Solar Radiation Storms expected.
Electron flux is at background levels. An increase to High is likely by late Day 2 or Day 3 (06-07 Dec) as the electron belts relax as the influence of the HSS wanes. The associated 24 hour electron fluence is expected to remain below the Active threshold, but gradually increasing from Day 2 onwards with a chance of exceeding the Active threshold later Day 3 or Day 4 (07-08 Dec).

Figure 1. Solar Analysis Valid 04/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME that left the Sun in association with the M1.1 flare from AR3500 at 01/2120 UTC may give a glancing blow in the early hours of Day 1 (05 Dec). The CME produced by a filament eruption around 04/0700 UTC is expected to miss, however, there is a slight chance of some enhancement and a glancing blow on Day 3 (07 Dec). No further CMEs are currently thought to be Earth-directed.

Solar winds are currently at Elevated levels (520-560 km/s) due to the anticipated enhancement from a HSS from CH76/-. Enlil is currently providing good guidance on wind speeds. This coronal hole is a persistent feature and similar in size and position to the previous rotation. However, during the previous solar rotation a CME arrival masked the initial influence of the coronal hole. Strong winds of around 600-620km/s may occur at the peak during Day 1. Elevated speeds are likely to persist throughout Days 1-2 (05-06 Dec) before easing to Slightly Elevated levels on Day 3 (07 Dec). Should the glancing CME arrive on Day 3, some minor enhancement to wind speeds may be observed.

Geomagnetic activity is expected to be largely Quiet to Unsettled through the forecast period (Kp 0-3). There is a chance in the early hours of Day 1 that a combination of influences from the HSS and a potential CME arrival may see activity increase to Active (Kp 4) or G1/Minor Geomagnetic Storm (Kp 5) levels. There is a slight chance on Day 3 (07 Dec) that a glancing blow from a CME produce an Active or G1/Minor Geomagnetic Storm interval, but this is considered a low probability, with Enlil modelling a miss below Earth's orbit.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	5	10	1
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
02/0440	Partial	M1.0 Flare AR3500	SW	585 km/s	05/0100 UTC	Chance of glaning blow with limited shock.
04/1222	Partial	Filament near AR3511	SE	630 km/s	07/1200 UTC	Slight chance of glancing blow with minimal shock impacts.

Figure 2: MOSWOC Enlil showing potential CME arrival early Day 1 concurrent with HSS.

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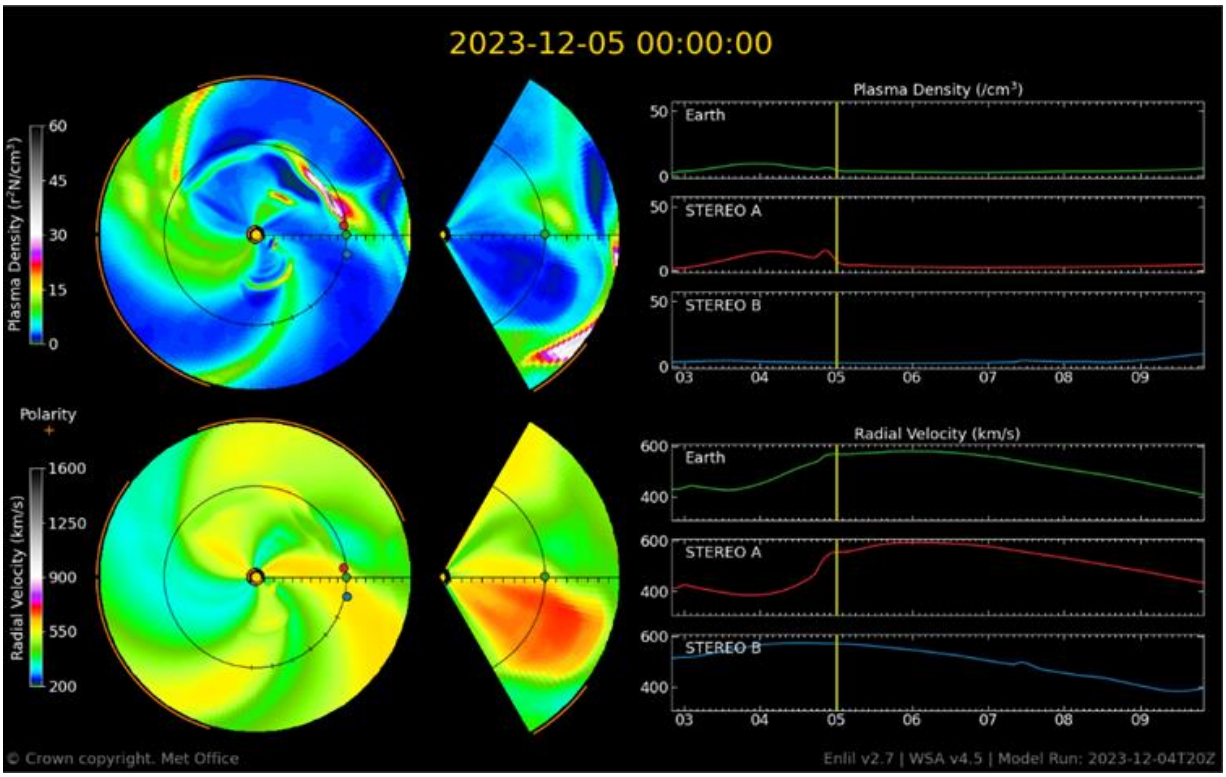
Met Office Space Weather Technical Forecast



Radio Blackouts - X-Ray Flares:

The largest flare of the past 24 hours was a C8.1 flare at 04/0126 UTC from AR3511.

There are currently nine sunspot regions on the disc, with one new region recently emerging on the northwestern disc. AR3500, is now approaching the southwest limb and has remained relatively stable. AR3510 and AR3511 in the southeastern quadrant approaching centre disc continue to develop. AR3511 maintains a delta group in its central portion. AR3507 (Dso/Beta) is the largest region on the disc and has developed slightly in the past 24 hours but remains largely stable. The remaining regions on the visible disc are mature and stable or in slow decay.

AR3500 is due to depart the disc during Day 1. A new region is currently emerging from the northeast limb and has produced a number of C-flares already. Otherwise, no further significant returning or new regions are expected to rotate over the eastern horizon in the coming days and the flare probabilities have been adjusted to reflect this.

Solar activity is expected to be Low with a chance for isolated M-flares (R1-R2 Blackouts) Day 1-2 (05-06 Dec), reducing to a slight chance on Days 3-4 (07-08 Dec).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	30	15	15
Very Active	R3 to R5 X Class	No	5	3	1	1

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Figure 3: GOES16 and GOES18 X-Ray trace over past 24 hours.

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background and is expected to remain at this level. There is a very slight chance of S1/Minor Storm conditions being reached on Day 1 (05 Dec) should any significant flares occur, mainly from AR3500 on the western limb. The risk diminishes by Day 2 (06 Dec) as the region rotates further beyond the visible disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	3	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

Electron flux is at background levels with the Van Allen belts still suppressed following recent enhanced geomagnetic activity. Continued suppression is expected as a result of geomagnetic activity associated with the HSS from CH76/- and a potential CME arrival early Day 1 (05 Dec). An increase to High levels is likely by late Day 2 or Day 3 (06-07 Dec) as the electron belts relax back towards ambient positions. However, the slight chance of a glancing blow from a CME on Day 3 reduces confidence in the forecast.

The associated 24 hour electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold. However, a rising trend is likely from Day 2 onwards with a chance of exceeding the Active threshold later Day 3 or Day 4 (07-08 Dec). REFM is considered to be providing reasonable guidance.

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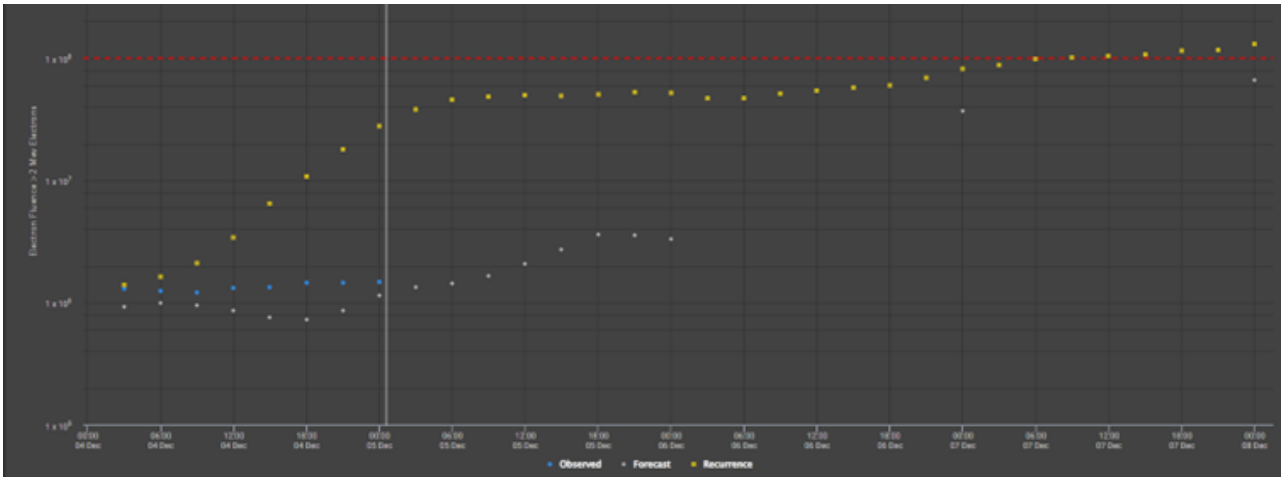
GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	30	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: MOSWOC REFM considered good guidance. Approaching Active levels Day 3-4.



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